INFORMATION REPORT INFORMATION REPORT

CENTRAL INTELLIGENCE AGENCY

C-O-N-F-I-D-E-N-T-I-A-L

[redacted]

50X1-HUM

COUNTRY USSR

REPORT [redacted]

SUBJECT Evaluation Study of the Soviet Drobyshev Stereometer STD-2

DATE DISTR. 21 July 1960

NO. PAGES 1

REQUIREMENT NO. RD

REFERENCES

DATE OF INFO. [redacted]

PLACE & DATE ACQ. [redacted]

50X1-HUM

SOURCE EVALUATIONS ARE DEFINITIVE. APPRAISAL OF CONTENT IS TENTATIVE.

50X1-HUM

[redacted]

1. [redacted] photographs and diagrams, of a Soviet topographical instrument, the Drobyshev stereometer STD-2 [redacted]

2. The study contains a description of the plotter, principal technological data, sign rules and basic relations, results of operating tests and adjustments, and the method of orienting aerial photographs.

50X1-HUM

[redacted]

50X1-HUM

C-O-N-F-I-D-E-N-T-I-A-L

[redacted]

50X1-HUM

STATE	X	ARMY	X	NAVY	X	AIR	X	FBI		AEC		NIC	X	NSA	X
										PIC	X	ORR/EV	X		

(Note: Washington distribution indicated by "X"; Field distribution by "#".)

INFORMATION REPORT INFORMATION REPORT

 50X1-HUM

[redacted]

I DESTINATION OF THE TOPOGRAPHIC STEREOMETER STD-2

[redacted] 50X1-HUM

The topographic stereometer STD-2 is to be used for drawing contour lines on aerial photographs and is one of the instruments of the differentiated method for aerial photographic height survey. The stereophotogrammetric measurements to be carried out with the instrument consist in determining the difference in the x-parallaxes of the photographed terrain points. In order that the measured differences in the x-parallaxes correspond with the horizontal aerial photographs, obtained at a horizontal position of the base-line, corrections are automatically applied to the values measured by means of special correction devices. The change of difference in the x-parallaxes, connected with the tilt angles of the aerial photographs or with the tilt of the base-line, takes place in proportion to the correlations between the current coordinates of the points under observation and is expressed in its general form by the formula:

$$dP = k_1x^1+k_2x^{12}+k_3x^1y^1+k_4y^1+k_5\Delta P+k6x^1\Delta P+k_7y^1\Delta P+k_8\Delta P^2 \qquad (1)$$

in which $k_1,k_2,k_3,k_4,k_5,k_6,k_7,k_8$ are the coefficients depending on the elements of outer and inner orientation;
x and y are the current coordinates of the observation point

ΔP is the difference in the x-parallaxes.

For the automatic application of corrections to the measured differences in the parallaxes, the topographic stereometer is provided with six correction devices, taking into account the influence of the first, second, third, fourth, sixth and seventh term of above mentioned formula. When working with the instrument, the influence to the fifth and the eighth term is taken into account in an analytical way. The adjustment of the correction devices of the topographic stereometer into the right position, whereby the differences of the x-parallaxes measured will be free of changes, caused by the tilt angles of the base-line and the aerial photographs, is called orientation of aerial photographs with the stereometer. The orientation of the aerial photographs with the stereometer takes place either according to the elements of inner and outer orientation known beforehand, or in accordance with the quotes of four points which are represented on the aerial photographs. For working with the instrument

[redacted]

50X1-HUM

photoprints are used, which are made on photographic paper pasted beforehand on glass to prevent deformation.

After orientation of the aerial photographs set on the instrument the countour lines are drawn, with a pencil directly by hand on the right aerial photograph. Afterwards, the aerial photographs on which the countour lines have been traced, are used for carrying over the latter to the photoplan or for composing a graphic plan.

For working with the instrument aerial photographs size 180 x 180 mm are used, which have been obtained by aerial camera's with any focal length at tilt angles up to 5°. The topographic stereometer STD-2 is used when composing topographic maps in a scale from 1 : 5000 up to and including 1 : 100 000.

II DESCRIPTION OF THE TOPOGRAPHIC STEREOMETER STD-2.

On the immovable foundation 1 (fig. 1 and 2) of the topographic stereometer guiding rails (slides) are situated, along which the main support 5 (fig. 1, 2 and 3) is moved by turning the rack 2. The direction of the displacement of the main support is the direction of the axis x-x of the instrument. On the main support two carriages are situated - the left one 6 and the right one 7 with the plate holders 8 and 9. On the pl. h. 8 and 9 aerial photographs are mounted, which form a stereopair and are fastened with the clamps 11. The plate holders can rotate in their planes by means of the screws 10 (fig. 1); the position of the rotation axes is marked by a cross. The deflection angle of the plate holders is read off from the scale and the vernier (nonius) with an accuracy of 2' (sexagesimal).

The carriages 6 and 7, may, besides displacements together with the main support, also have independent displacements along the axis x-x of the instrument for measuring the difference of the x-parallaxes. The left carriage is moving with regard to the main support by rotation of the x-parallax-screw 47 (fig. 1 and 3). The magnitude of this displacement is read on a scale with an accuracy of 0.01 mm.

The right carriage (fig. 2) is automatically displaced with regard to the main support under the influence of the correction rulers 13 and 14 (fig. 3) which have a joint rotation around the fixed axis 4. The edge of the ruler 13 is always in contact with the ball-race 16, connected with the slide 48; this slide bar can move in any-direction under the influence of the ruler 19 within a small range along the rail 12, attached on the main support. The rib of the ruler 14 is also always in contact with the ball-race 18, on the vernier slide 49. The Vernier slide 49 can be adjusted in position on the rail 17, connected with the right carrier 7.

In the initial position, the correction rulers 13 and 14 are parallel, whereas the distances from the rotation axis 4 to the ball-races 16 and 18 are equal. Therefore, the main support with the ball-race 16, moving along the axis x-x of the instrument, pushes the ruler 13 during rotation of the rack 2, which ruler is rotating around the axis 4 by the angles i, to be determined (fig. 4) by the function

$$\tan i = \frac{x}{d}$$

in which x = the abscissa of the observation point of the RH photograph (the distance covered by the main support); d = the distance from the axis 4 to the ball-race 16, measured in a direction which is perpendicular to the axis x-x.

The second ruler 14 will also turn by the same angle i (as it is attached to the right carriage 7 by the amount

$$x' = d' \tan i \qquad \text{(b)}$$

in which d' = the distance from the axis 4 to the ball bearing 18.

As in the initial position d' = d, x' = x, i.e. the right carriage will be moving by the same amount as the main support. Therefore, there will be no extra movement of the right carriage, when the main support with the right carriage is moving by the magnitude x.

If however, by screw 50 the Vernier slide 49 with the reel 18 is displaced along the rail 17, the lengths d and d' of the correction rulers

will be different. In this case, the right carrier 7, together with the main support, will be displaced by the distance x, whereas the ruler 14 makes that it moves by the amount x'. The extra movement of the right carriage with regard to the main support will then be expressed by the magnitude.

$$\Delta x_1 = x' - x = \frac{x}{d}(d' - d) = \frac{x}{d}\cdot\Delta d \qquad (2)$$

Moreover, if even the lengths d and d^1 of both rulers are equal, but the rulers are not parallel to each other, the right carriage 7 also obtains an extra displacement along the axis x-x. Thus, if between the rulers 13 and 14 the angle β is introduced (fig. 5), both rulers will turn by the angle i, determined by the function (a), during displacement of the main support by the distance x. The ruler 14 will displace the ballrace 18 and the right carriage by the amount

$$x' = d \tan(i + \beta) - d \tan \beta$$

Then the independent displacement x_2 of the right carriage will be represented by the function

$$\Delta x_2 = x' - x = d\left[\tan(i + \beta) - \tan\beta - \tan i\right]\frac{x^2}{d}\tan\beta \qquad (3)$$

The angle β between the rulers can be changed after release of the clambing screw 15, whereas this angle is introduced on the scale with an accuracy of 2'.

The difference in length of the rulers in the instrument cannot only be changed by rotation of the micrometer screw 50, but also automatically, as a result of the movement of the slide 43 under the influence of the ruler 19. For that purpose, the ruler 19 (fig. 6) can rotate around the axis 52, which is connected by the bracket 20 with the left carriage 6 Along the ruler 19 the ball-race 21 attached on the slide 48 is sliding, the centre of which coincides with the axis 52 in the zero position. During the displacement of the main support the ball-race 21 and the ruler 19 do not change their position. But, the ruler 19 is displaced with regard to the ball bearing 21, when the left carriage is moved by the x-parallax-screw 47. If the ruler 19 forms the angle γ_1 with the direction of the axis x-x of the instrument, the slide bar 48 with the

ball-race 21 is moving along the rail 12 when the left carriage is moving from the zero position by the amount ΔP. This causes a change of the difference in length of the rulers by the amount

$$\delta d = \Delta P . \tan \gamma_1$$

Later on, when the main support is moving, such a change of difference in the length of the rulers will cause an extra displacement of the right carriage by the amount

$$\Delta x_3 = \frac{x}{d} \delta d = \frac{x\Delta}{d} \cdot \tan \gamma_1$$

Before the work the instrument is put into operation the shaft of the locater (index pin) 22 (fig. 2) has to enter into a special opening of the ruler 19, whereas the screw 23 (fig. 7) has to be loosened. Then, by turning the x-parallax screw the bracket 20 will glide along the axis 52 of the ruler 19; in this case the correction mechanism does not work. Rotation of the x-parallax screw will lead to a break-down of the instrument, when the locater has been switched on and the screw 23 has been fastened; therefore above mentioned condition should be carried out very carefully.

To put the given correction device into operation, the first reading is established on the scale of the x-parallax screw (corresponding with the combination of the spatial hair and the starting point of the model), the screw 23 is fastened, the locater 22 is released and the ruler 19 is turned by the angle γ_1 with the eccentric 24. In this case, by further rotation of the x-parallax screw the ruler 19 is moved together with the bracket 20 along the axis x-x of the instrument and puts the ball-race 21 into movement along the rail 12. For switching off the correction device, when passing to the next stereopair, the screw should be loosened and the loosened and the locater should be switched on.

The angle γ_1 of deflection of the ruler 19 can be established on a scale with an accuracy of 5^1.

The measuring marks in the topographic stereometer are two hairs fixed in the holders 33 (fig. 2) which can rotate around fixed vertical axes, 25 (fig. 8) connected with the foundation of the instrument. The

two guide rods 26 and 28 are connected with the right thread holder (fig. 8); between these guide rods the angle hair can be established by means of the screw 31. The guide rod 28 with the length r terminates in the ball-race 27, which always is in contact with the ruler 29. The ruler 29 can rotate around the axis 30, which is rigidly attached to the right carriage.

If the ruler 29 is parallel to the axis x-x of the instrument, then the ball-race 27 will glide along the ruler 29 and the thread holder will not move when the main support moves. In this position the hair (thread) will not be perpendicular to the axis x-x of the instrument, if between the guide rods the angle hair was introduced. Then the abscissae of the R.H. photograph (fig. 9) will be changed by $\Delta X_4 = y \tan x_{thread}$. (5)

If, however, the ruler 29 is rotated about its axis by the angle ρ_o, then the ruler 29 will push the ball-race 27 when the main support is moved, which will cause a deflection (deviation) of the guiding rod 28 (fig. 8) and the thread holder connected with it by the angle ρ. In that case the relation between the angles ρ_o and ρ (fig. 10) will be represented in the form

$$\tan \rho = \frac{x}{r} \tan \rho_o$$

Due to the deflection of the hair the abscissae of the points of the right aerial photograph will change by the magnitude

$$\Delta x_5 = y \tan \rho = \frac{xy}{r} \tan \rho_o \qquad (6)$$

The ruler 29 is turned by the micrometer screw 3. and the angle of deflection is read off from a scale with an accuracy of 2'.

The left hair holder 33 is rigidly connected with the guiding rod 53 (fig. 11) with a length R, which terminates in the ball-race 37. The rod 34 is restrained to move in y-direction by the rails 54. It has an arm pointing to the right, which is always in contact with the ball-race 37. The rod itself terminates in the ball-race 38. The ball-race 38 gets into contact with the correction ruler 35, which can rotate around the pivot 36, attached on the foundation 39. The latter is attached to the left

carriage by means of the fastening screw 40.

When the main support moves, the arm of the rod 34 is sliding along the ball-race 37 and no deflection of the thread holder takes place. When, however, the left carriage is moving by the magnitude ΔP by means of the x-parallax screw 47, whereas the ruler 35 has been turned by the angle γ_2, this ruler moves the rod 34 along the rail 54 by the amount

$$k = \Delta P \tan \gamma_2$$

This moves the ball-race 37 by the same amount which causes a deflection of the thread holder by the angle

$$\delta x = \frac{k}{R}$$

The change of the abscisss of the left aerial photograph will be determined by the function

$$\Delta x_{\delta} = y \tan \delta = \frac{yk}{R} = \frac{y\,\Delta P}{R} \cdot \gamma_2 \qquad (7)$$

Before operating with the instrument, the locater 42 (fig. 1) should be switched on, which corresponds with the connection of the main support with the foundation 39 (fig. 11). In this case the fastening screw 40 should be loosened, because otherwise the rotation of the x-parallax screw would lead to a break-down of the instrument. Rotation of the x-parallax screw causes a displacement of the left carriage 6, which will move along the foundation 39 when the screw 40 has been loosened. Therefore the given correction device does not work.

To switch on the correction device, the first reading is established on the x-parallax screw, the ruler 35 is turned by the angle γ_2 and fasened with the screw 41 (fig. 1), the foundation 39 is attached to the left carriage with the screw 40 and the locator 42 is released. When the device is switched off, the screw 40 is loosened and the locator is mounted. The deflection angle γ_2 of the ruler 35 is introduced on a scale with an accuracy of 5'.

The various points of the stereopair are observed by means of a stereoscope, the carriage 44 of which is moved along the rail 3 by the

rotation of the rack 45. The stereoscope consists of two pairs of mirrors (fig. 12), between which lenses are placed assuring an enlargement of 2,5 x. To eliminate the observed y-parallax, the left lens is displaced perpendicular to the optic basis by an amount of $\pm$ 6 mm by means of the micrometer screw 55 (fig. 1). To establish the optic basis of the observer, the small mirrors can be moved apart by a value of $\pm$ 8 mm from the mean value, which is equal to 66 mm., by means of lathe carrier 46 (fig. 1).

The stereoscope is incorporated within a metal body 43 (fig. 1), behind which an illuminator is attached, consisting of two incandescent lamps and reflectors. At the top the illuminator is covered by a frosted plate of plastic protecting the body from heating.

III MAIN DATA OF THE INSTRUMENT.

1. Displacement of the main support (to the left 40 mm, to the right 85 mm)	:	125 mm
2. Change of the x-parallaxes	:	35 - 85 mm
3. Distance between the measuring hairs	:	175 mm
4. Enlargement of the stereoscope	:	2,5 x
5. Field of view of the stereoscope	:	45 x 60 mm
6. Distance from the rotation centre 4 of the rulers to the reel 16	:	100 mm
7. Change of the distance d' from the rotation centre 4 to the reel 18	:	90 - 120 mm
8. Change of the angle β between the correction rulers 13 and 14	:	$\pm 5^{\circ}$
9. Change of swing $\varkappa_1$ and $\varkappa_2$ of the plate carriers	:	$\pm 12^{\circ}$
10. Change of the angle $\varkappa_{hair}$ of constant delfection of the hair	:	$\pm 5^{\circ}$
11. Change of the angle ρ_o, causing alternative deflection of the hair	:	$\pm 6^{\circ}$
12. Change of the angle γ_1, causing difference in lengths of the rulers	:	$\pm 7^{\circ}$
13. Change of the angle γ_2, causing deflection of the left hair	:	$\pm 8^{\circ}$
14. Radius r of deflection of the right hair	:	86 mm
15. Radius R of deflection of the left hair	:	135 mm

16. Accuracy of reading from the scale x–x at interpolation : 0.1 mm
17. Accuracy of reading of the x-parallax-screw : 0.01 mm
18. Accuracy of reading from the scale d' : 0.1 mm
19. Accuracy of reading from the scale x_1, x_2, β, x_{thread}, p_o : 2'
20. Accuracy of reading from the scales γ_1 and γ_2 : 5'

IV. SIGN RULES AND BASIC RELATIONS.

The values established on the correction device of the topographic stereometer are connected with the elements of outer orientation of the aerial photographs by the relations:

$$\beta = -\frac{d}{c}(\varphi' - \varphi'')$$

$$p_o = +\frac{r''}{c}(\omega' - \omega'')$$

$$\Delta d = +\frac{d}{c}\,\frac{(Z_R' - Z_R'')\,c}{Z_R'} + 2\,P_R \cdot \varphi'.$$

$$x_{thread} = +\frac{P_R}{c}\,\omega'$$

$$\gamma_1 = +\frac{2d}{c}\cdot\varphi' = +\frac{\Delta d}{P_R}$$

$$\gamma_2 = +\frac{r'}{c}\cdot\omega' = +\frac{r'}{P_R}\,x_{thread}$$

In which:

d = distance in y-direction from pivot 4 to ballrace 16, slide 48 in zero position = 100 mm.
c = taking camera principal distance.
r" = radius of deflection of the right hair = 86 mm.
r' = radius of deflection of the left hair = 135 mm.
P_R = stereoscopic parallax of the reference point.
Δd = difference in length of the correction rulers.
Z_R'' and Z_R' = flying height over reference of the RH and LH camera
φ', φ'', ω', ω'' = longitudinal and lateral tilts of the left and the right aerial photograph.
x_{thread} = angle of contact deflection of the thread.

The positive values of the longitudinal and the lateral tilt are shown on fig. 14. The positive values establishes on the correction devices of the stereometer are shown on fig. 13.

V. OPERATING TESTS AND ADJUSTMENT OF THE TOPOGRAPHIC STEREOMETER.

Operating tests and adjustment of the instrument are carried out during the inspection (acceptance) in order to determine whether the topographic stereometer is suitable for further operation and to establish the readings on the scales of the correction devices corresponding with the initial (zero) position. The operating tests are carried out by means of an indicator and measuring grids mounted on the right and the left plate-holders. For checking, small knots are tied on the measuring hairs, determining the position of the sighting marks.

During the adjustment of the topographic stereometer it is ascertained whether:

1. the guide rails of all carriages are rectilinear and parallel to each other;
2. the rotation centres of the plate-holders of both aerial photographs coincide with the crosses on the carriages;
3. the line, joining the rotation centres of the plate-holders is parallel to the x-x axis of the instrument;
4. the horizontal arm of the rod 34 is parallel to the x-x axis of the instrument;
5. the guide rail 17 is perpendicular to the x-x axis of the instrument;
6. the quality of the image observed is good;
7. the rotation axes of the plate-holders are situated in line with the rotation axes of the hair holders when sighting to the rotation centres of the plate-holders;
8. the right hair passes through the rotation centre of the right plate-holder at the initial position;
9. the scales are applied and the screws of the instrument are made with the required accuracy.

The rectilinearness and mutual parallelism of the guiding rails of the carriages are checked by means of grids, which are mounted on the plate-holders of the instrument, when the mean intersection of the lines of the grid coincides with the rotation centre of the plate-holder. At that moment, the small knot, tied on the hair, should also coincide with the mean intersection of the lines of the grid. By rotating the rack of the main support it is displaced to the left, whereas the small knot of hair should all the time coincide with the same horizontal line of the grid, with which it has coincided in the initial position. When there is no coincidence, the clamping screw of the plate-holder is loosened and by turning the plate-holder by the angle x , the small knot of thread is brought in line with the chosen stroke.

After this, during rotation of the rack, the knot of thread should all the time move along the chosen horizontal stroke with a deviation of not more than 0.1 mm. When the displacement of the knot of thread exceeds the permissible movement, it proves that the guide rails are not rectilinear, which should be corrected by the mechanic . Furthermore, if the left carriage is displaced by rotating the x-parallax screw or the right carriage by changing the angle [illegible] between the correction rulers, the knots of thread should move along the same horizontal strokes with an error of not more than 0.2 mm. When the error is larger than allowed it points to the fact that all three guide rails are not parallel, which is also eliminated by the mechanic.

When the plate-holder with the grid is rotated in its plane by the angle x , the central intersection of the grid lines should not leave the cross on the axis of the plate-holder; a displacement by a value greater than 0.3 mm is corrected by the mechanic.

The location of the rotation centres of both plate-holders on one straight line, parallel to the x-x axis of the instrument, is checked after both grids have been mounted on the plate-holders and when their horizontal strokes coincide with the direction of the x-x axis of the instrument. Then the thread is stretched over the grids and is brought in line with the horizontal stroke of one grid. The corresponding stroke of the second grid should coincide with the stretched thread with an error

of not more than 0.2 mm; in case of non-coincidence, it is remedied by the mechanic.

The parallelism of the horizontal arm of rod 34 of the x-x axis of the instrument is checked by displacing the main support along the x-x axis; in this case, the thread-holder should not rotate in its plane.

By means of the right thread it is ascertained whether the right guide rail 17 of the vernier slide bar 49 is perpendicular to the x-x axis of the instrument. To this end, by displacing the main support the right thread is brought in line with the intersection of the strokes of the orientated grid, which intersection coincides with the rotation centre of the right plate-holder. If in the given position the thread does not coincide with the vertical stroke of the grid, such a coincidence is attained by bending of x_{thread}. When the main support is displaced, the right thread should coincide with all other vertical strokes; if this condition is not fulfilled, the angle ρ_0 changes. As a result of such actions, the right thread always keeps a position that is perpendicular to the x-x axis of the instrument. After this, the adjusting screw 15 is loosened and by displacement of the main support the right thread is mounted the edge of the guide rail 17. For the edge of the guide rail 17 and the right thread an unparallelism of not more than 0.1 mm is allowed.

The quality of observation with the stereoscope is checked by stereoscopic observation of the grids orientated in the instrument. Corresponding horizontal lines of the grids must be fused without any strain of the eyes. If, however, corresponding horizontal lines bifurcate or are seen not parallel, there must be a lateral deflection of one of the mirrors.

Whether the rotation centres of the plate-holders are collinear with the rotation centres of the thread-holders is checked after all correction devices have been set in the initial position. Then, after having brought the right thread in line with the rotation centre of the right plate-holder, the rulers 26 and 29 should be turned by as large as possible angles. If, at such rotations, the thread will not leave the rotation centre of the plate-holders by values greater than 0.2 mm, the condition is considered to be fulfilled; if not, the mechanic should move the rotation axis of the thread-holder. Just in the same way, the left thread,

brought in line with the rotation centre of the left plate-holder, should not leave the centre at the greatest values of the angle γ_2 and for large differences ΔP in x-parallax. It is ascertained if the right thread passes through the rotation centre of the right plate-holder, after having put the scale x of the instrument into the initial position. In this case, the right thread should pass through the rotation centre of the right plate-holder with an error not exceeding 0.5 mm. When this condition is not fulfilled, it has to be remedied by displacing the rotation centre of the correction rulers.

The scales and the operation of the screws of the instrument are checked by means of a measuring dial, which is fastened on the immovable foundation of the instrument; the pin of the indicator should rest against the left carriage. The displacement of the left carriage with the screw of the x-parallaxes causes a change in the readings on the scales of the indicator and the parallactic screw and these changes have to be equal to each other.

Defects of the instrument noted after the tests can only be remedied by the mechanic.

The index-errors c.q. initial settings have to be determined in this sequence:

a. the β-scale (15) and the difference $(d' - d) = \Delta d$
b. the x-scale (60).
c. the x_t-scale (31).
d. the ρ_0-scale (32).
e. the determination of the value d' for a given setting of scale (17).
f. the x parallax screw (47).
g. the γ_1-scale (19).
h. the γ_2-scale (41).
i. the determination of r' and r"

a. The zero point of the β-scale and the difference $(d' - d)$ are determined from x-parallax measurements on three points of the grid plates. These points are chosen and numbered as in the diagram 14a.

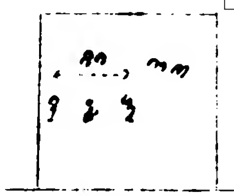


fig. 14 a

The point 1 is the RH plate carrier rotation centre.

The readings are P_1', P_2' and P_3'. The index error ε_β of the β scale is then determined by

$$\varepsilon_\beta = \beta + 108\,(P_1' + P_2' - 2P_3') \qquad (9)$$

In which β' is the initial setting of the β-scale. The results are expressed in sexagesimal minutes. Introduce ε_β on the scale. The Δd is determined by

$$\Delta d = - \frac{P_1' + 3P_2' - 4P_3'}{0.8} \qquad (10)$$

Δd is annulated by changing the reading of the d' scale by this amount, which must be done before proceeding.

b. Determination of the zero-point of the x-scale. Shift the x-carriage until the RH thread passes through the RH centre-cross. Vary the d by means of rotation of the ruler 19, after having released the locator 22, the clambing screw of the γ_1 scale and the screw 23. If the plate-holder moves due to the d-variation, shift the x-carriage until it stops moving. Now the ruler 13 must be parallel to the guide-rail 17. This guide-rail was adjusted to be perpendicular to the x-rail at the factory. The x reading is now noted.

c. The scale for the x_{thread} (31) must read zero if the right thread is parallel to the vertical grid line passing through the centre-errors. (Previously the x was set to zero by means of the knot on the right thread. Check this!).

d. The ρ_o scale must read zero if the RH thread is parallel to all other grid-lines in y-direction. Check this on the line x = 80 mm.

e. The value d' is found in the following way:
Put the right thread on the grid line for which x = 80 mm. Read the vernier (d_1') Change this reading until the right thread is on the line x = 70 mm. Read the vernier again (d_2'). The d_o is then:

$$d_o = \frac{80}{80 - 70} \cdot (d_1' - d_2') \qquad (11)$$

f. The index-error of the x-parallax-screw is determined from

$$\varepsilon_P = P_x - (x_L - x_R)$$

In which x_L = the x-reading of the LH principal point
x_R = the x-reading of the RH principal point.

g. The γ_1-scale must read zero when the RH plate holder does not move when the x-parallax-screw is turned over some centimetres. The locator must be loose, screw 23 clamped.

h. The γ_2-scale is checked with the LH thread, if γ_2 is zero, the thread may not pivot. Check this on a point $y = \pm 80$.

i. r' and r" are, as d_o instrumental constants. r' is determined in the following way (fig. 15).

Put the γ_2-lever at its maximum. Observing with the left eye make coincidence of the thread with a vertical grid line. Read the P_x-screw and then turn it until the thread has an inclination, relative to the grid of arctan $\frac{\Delta x}{y}$. Read P_x again. r' is now computed from:

$$r' = \frac{y}{\Delta x} \cdot \Delta P_x \cdot \frac{\gamma_2}{3438} \qquad (12)$$

The r" is determined in a similar way (fig. 16), now using the right thread with the formula

$$r' = \frac{xy}{\Delta x} \cdot \tan \Delta\rho \qquad (13)$$

In which x and y are the coordinates of the point under observation and Δx the displacement of the RH thread due to a change $\Delta\rho$ on the ρ scale.

After having determined all these constants it is possible to set the elements of the instrument if the orientation elements of the photographs are given.

VI. ORIENTATION OF AERIAL PHOTOGRAPHS WITH THE STEREOMETER.

Aerial photographs are orientated with the stereometer according to control points known in height. Taking one of the control points as

the reference point, the height differences Δh of all other points with regard to the reference point can be determined, whereas according to formula

$$\Delta P = \frac{P_R}{Z_R - \Delta h} \cdot \Delta h \tag{14}$$

the differences in the x-parallaxes can be found, which should be measured at a horizontal base-line and horizontal aerial photographs.

The heights of four points (3, 4, 5 and 6), located as shown on fig. 17, are determined on two aerial photographs forming a stereopair. For these aerial photographs the mutual longitudinal ($\Delta\varphi$) tilt, the mutual lateral tilt ($\Delta\omega$), the flying height Z_R above the reference plane and the stereoscopic parallax of the reference point P_R are found first of all.

By rotating the rack (2), the main support of the stereometer is moved until the right thread passes through the rotation centre applied on the axis of the carriage. In this position, a small knot is tied on the thread, which should coincide with the rotation centre. The right aerial photograph is mounted on the plate-holder under the thread in such a way that its principal point coincides with the knot and the line connecting the principal points of two aerial photographs is nearly parallel to the x-x axis of the instrument. Thus, by rotating the rack, the left thread is brought in line with the rotation centre of the left plate-holder, the knot is tied on the left thread and the left aerial photograph is placed on the plate-holder. The overlapping parts of both aerial photographs should be arranged inside the instrument and the photographs should be fastened on the plate-holders by means of clamps.

The photographs are oriented with respect to the flight line in the following way. Observe the point 1 (LH principal point). Make coincidence between the two knots in x direction with the x-parallax-screw (47) and in y-direction with the RH x (10).
Observe then the point 2 and eliminate y-parallax between the knots with the LH x screw. After having repeated this once or twice one should have an undisturbed stereoscopic image and the two knots are taken away.

Then proceeding directly to the orientation itself with the stereo-

meter, it is necessary to establish first of all the angles β and ρ_o between the correction rulers, so that the position of all other correction devices may correspond with their zero value. To this end, a reading from the scale d' is stated by displacing the slide bar 49 along the guide rail, which is just equal to 100 mm, and according to the scales x_{thread}, γ_1 and γ_2 readings are stated which are equal to zero. The angles β and ρ_o are calculated according to the formulae:

$$\beta = - \frac{d}{c} (\varphi' - \varphi'') \qquad \rho_o = + \frac{r''}{c} (\omega' - \omega'') \qquad (8)$$

in which d = 100 mm,

c = principal distance,

r"= 86 mm.

The orientation begins from point 4, which is taken as the reference point. The spatial mark is brought in line two times successively with this point by the stereoscope and the average from the two x-parallax readings is entered in the column "Reading" of the journal used for orientation (table 1). The difference between the two readings should not exceed 0.02 mm; when the value of this magnitude is greater, it is necessary to repeat sighting. In the same way, the spatial mark is brought in line with point 6 and the average from the two readings is entered in another line of the same column.

In the column "Should be" the sum of the reading, obtained when bringing the spatial mark in line with point 4, with the difference of the x-parallaxes of point 6 calculated from the known height difference, is entered. The difference between the measured and the calculated readings is entered for point 6 in the column "Difference". If the obtained difference proves to be greater than 0.02 mm, it is eliminated by turning of x_{thread} (31) of the right thread in its plane. To this end, the obtained difference is multiplied by the quotient of the ordinate of the fourth over the difference in the ordinates of the sixth and the fourth point and the quantity then obtained is subtracted from the calculated reading of the column (Should be) to the sixth point. The difference calculated in this way is set on the x-parallax screw, but then the spatial mark does not coincide with point 6 of the model of the terrain.

This coincidence is attained by turning the right hair in its plane by the angle x_{thread} (3) without changing the reading from the scale of the parallactic screw. After this, the spatial mark is again brought in line with point 4 of the model, and a new reading is taken, which is entered again in the column "Reading". Then the spatial mark is brought in line with point 6, and in the column of the journal the reading is entered, and also its value which has been calculated as the sum of the reading on point 4 and the calculated difference of the x parallaxes. When there is a lack of coincidence of more than ± 0.03 mm of the calculated and measured readings on the sixth point, the whole procedure should be repeated.

In the same way, the spatial mark is brought in line with point 3 and the obtained reading is entered in the column of the journal; the calculated reading is then obtained by summing up the last reading on point 4 with the calculated difference in the x parallaxes of point 3 with regard to point 4. If the difference between the measured and the calculated readings is more than ± 0.02 mm, this is eliminated by changing the length d' of the correction ruler (49). To this end, the reading entered in the column "Should be" is set on the x-parallax screw, whereas the spatial mark is brought in line with point 3 of the model by displacing the slide of the correction ruler.

After this, the spatial mark is brought in line with point 5 of the model whereas the x-parallax reading is entered in the journal; in the column "Should be" under point 5, the sum of the last reading on point 4 and the calculated difference in the x-parallaxes is entered. If the discrepancy between the measured and the calculated values exceeds ± 0.02 mm, the difference obtained should be multiplied by the quotient of the ordinate of point 3 over the difference of the ordinates of point 5 and 3, and the value calculated in this way should be subtracted from the reading "Should be" on point 5. The found value of the reading "Should be" is set on the x parallax screw, and the thread is put "on the ground" at point 5 by rotation of ρ_0 of the right thread (32). Subsequently, the spatial mark is brought in line again with point 3 of the model and the whole procedure is carried out a new until the

readings on points 3 and 5 prove to be equal to those which have been calculated beforehand.

As the actual location on the stereopair of the points whose altitudes are known, always differs from the theoretical scheme, the orientation procedure is carried out with successive approximations. After having carried out above mentioned procedure, it is repeated from the very beginning in the same succession, but by this time there are far less discrepancies than at the beginning. The discrepancies which have appeared again are caused by the fact that when there is no exact coincidence of the points with above mentioned scheme, the change of position of all following correction devices gives rise to a change in the x-parallaxes on the previous points. For instance, if x_4 or x are not equal to zero, the change of the angle ρ_0 or the difference Δd in the lengths of the rulers will lead to a change in the x-parallax of these points, which can lead to a slightly incorrect establishment of the angle x_{thread}. Therefore the orientation procedure is continued until the readings made on all four points coincide simultaneously with the values calculated beforehand.

In practice, it is efficient to carry out first of all an approximated orientation with conservation of the residual differences up to 0.1 mm, and after that to proceed to the final orientation according to the scheme stated above.

The results of the measurement, connected with the orientation of the stereopair are put down in the journal (table 1), in which the following order of recording is adopted. In column 1, the numbers of the points are written according to the order of orientation. In column 2, the altitudes of the control points with an accuracy up to 0.1 m, in column 3 their elevations over the reference point, in column 4 the calculated differences in the x-parallaxes, in column 5 the x-parallax readings of x-parallax.

The sum of the calculated difference in the x-parallaxes and the starting reading on point 4 is entered in column 6 and the difference between the measured and calculated readings in column 7.

After having finished the orientation, the observer should enter the readings from the scales of the correction devices in the journal.

As a result of the orientation, the measured x-parallaxes of all points of the stereopair will be free from any influence of the tilts of the aerial photographs and the difference in flying heights.

In some cases, the heights of six points located as shown on fig. 18, are known for orientation of aerial photographs with the stereometer. Then $x_2 = 0$, $y_2 = 0$; $x_1 = + \max$, $y_1 = 0$; $x_4 = 0$, $y_4 0 + \max$; $x_3 = + \max$; $y_3 = + \max$; $x_6 = 0$; $y_6 = - \max$; $x_5 = + \max$; $y_5 = - \max$, the heights of two points (usually the points 5 and 6 being regarded as check heights. In the above mentioned variant of situation of the known points the order of orientation somewhat changes. First of all, the spatial mark is brought in line with point 2 and this parallax reading, taken as the reference reading, is entered in the journal of orientation (table 2). After that, the spatial mark is brought in line with point 1, and the reading of the parallax screw is entered in the column "Reading" and the sum of the reference reading with the calculated difference in the x-parallax for point 1 is entered in the column "Should be". The difference between these two quantities is eliminated by changing the length Δd of the correction ruler (49).

To this end, the reading, which is equal to the calculated value entered in the column "Should be", is set on the parallax screw. The spatial thread will not be at the ground in point 1 of the model and to put it there, the position of the slider (49) on the guide rail of the correction ruler is changed. As a check, bring once again the spatial mark in line with point 1, but this time by means of the parallax screw, and if the reading from the parallax screw proves to be equal (with an error of not more than $\pm$ 0.02 mm) to the calculated reading, the orientation according to this point can be considered to be finished; when the readings do not coincide, the whole procedure should be repeated.

After establishment of the calculated reading for point 1 it is necessary to bring the spatial mark again in line with point 2 before proceeding to further orientation. If in that case the reference reading

has changed (which will occur due to an unstrict coincidence of point 2 with the principal point of the right photograph, it will be necessary to compute the new value in the column "Should be" and to repeat the whole previous procedure. Thus the reading measured for point 1 and the calculated reading will be equal according to the method of successive approximations with conservation of the initial reading entered in the journal.

In the same way, the spatial mark is brought in line with point 4 and the average from the two readings is entered in the column "Reading". A comparison of this reading with the calculated reading gives the difference δp_4, which should be eliminated by bending of x_{thread}. The calculated reading is the sum of the initial reading and the difference in the x-parallaxes calculated according to the elevation.

For this purpose, the calculated reading, entered in the column "Should be" is established on the scale of the parallactic screw, whereas the spatial mark is brought in line with point 4 of the model by bending of the right thread. As a check, the spatial mark is again brought in line with point 4, but this time by rotating the x-parallax screw and if the difference between the measured and the calculated reading does not exeed $\pm$ 0.02 mm, the orientation according to this point is considered to be finished; if it does, the procedure must be repeated.

After orientation according to point 4 the spatial thread should be brought in line again with point 2 and the initial x-parallax reading should be obtained. When the angle of bending of x_{thread} is considerable and point 2 deviates from the principal point, the initial reading will change and therefore it will be necessary to perform the whole orientation anew, beginning with the observation of point 1 and the change in the length of the correction ruler. As a result of such a succession in the execution of the work, the constancy of the initial reading and the equality of the readings measured and calculated directly for points 1 and 4 of the model should be observed.

Later on, the spatial thread is brought in line with point 3 of the model and the average from two readings is entered in the column "Reading" of the journal. If the sum of the initial reading and the calculated dif-

ference in the x-parallaxes, entered in the column "Should be", differs from the measured value more than $\pm$ 0.02 mm, the calculated value is established on the x-parallax screw, whereas the spatial mark is brought in line with point 3 of the model by changing the position of the correction ruler ρ_o. Later on, the spatial thread is brought in line again with all four points of the model in the succession as described above until the x-parallax readings are equal to the computed values for all points of observation. Besides the points 1, 2, 3 and 4, the spatial mark is also brought in line with points 5 and 6, which are check points. In that case, the difference between the measured and the calculated reading on points 5 and 6 should not exceed $\pm$ 0.03 - 0.04 mm after orientation of the aerial photographs according to points 1, 2, 3 and 4.

The efficiency of choice of the first method of orientation is connected with the extent of the necessary geodetic height control. When compiling maps for some territory and when using the first variant, the geodetic height traverses are laid in the zone of the lateral overlap between the strips, hereby assuring the determination of the marks of points 3, 4, 5 and 6 for all strips. In the second variant, height traverses passing in the middle of the routes, are added to these traverses, which nearly doubles the amount of the field work. However, the second variant has the advantage that the necessary check is directly obtained during the orientation procedure, which is impossible with the first variant. Nevertheless, the considerable increase of the field works in the second variant gives reason enough to consider the first variant more efficient.

The order of orientation as described above is, carried out when evaluating aerial photographs of a flat region, When a mountainous terrain is photographed, it is necessary to take into account the joint influence of the tilts of the aerial photographs and the elevations of the photographed points and to use two other correction devices of the instrument during the work. Therefore, after a preliminary orientation, carried out according to four points which have marks, readings are taken from the scales d' and x_{thread}, which make it possible to compute the angles γ_1

and γ_2 according to formula (8) and also the correction terms for all height points according to formula

$$\delta''_p = \frac{\Delta p \Delta d}{d} \qquad (15)$$

The calculated values of the angles γ_1 and γ_2 are established on the correction devices of the instrument, whereas the calculated differences in the x-parallaxes of all control points are corrected by the magnitude δ''_p. Such an establishment makes it possible to carry out a repeated orientation of the aerial photographs with the stereometer according to above mentioned scheme. The columns 1, 2, 3 and 4 (table 3) of the orientation journal are filled in before the first orientation, and the columns 5 and 6 before the second orientation.

CONFIDENTIAL

[redacted]

50X1-HUM

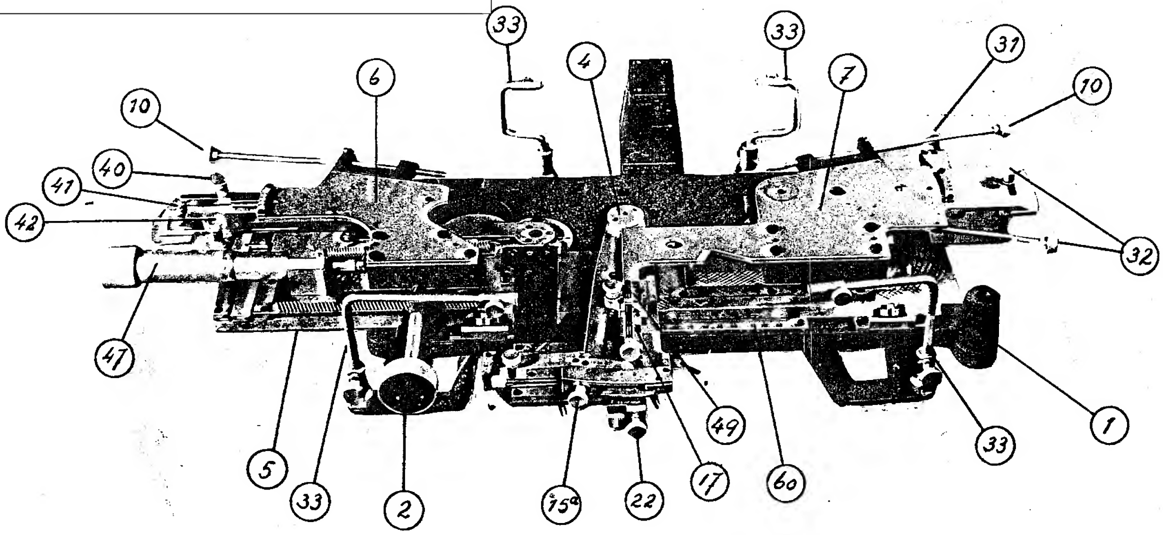
DIAGRAMS AND PHOTOGRAPHS OF THE STD-~~6~~ 2

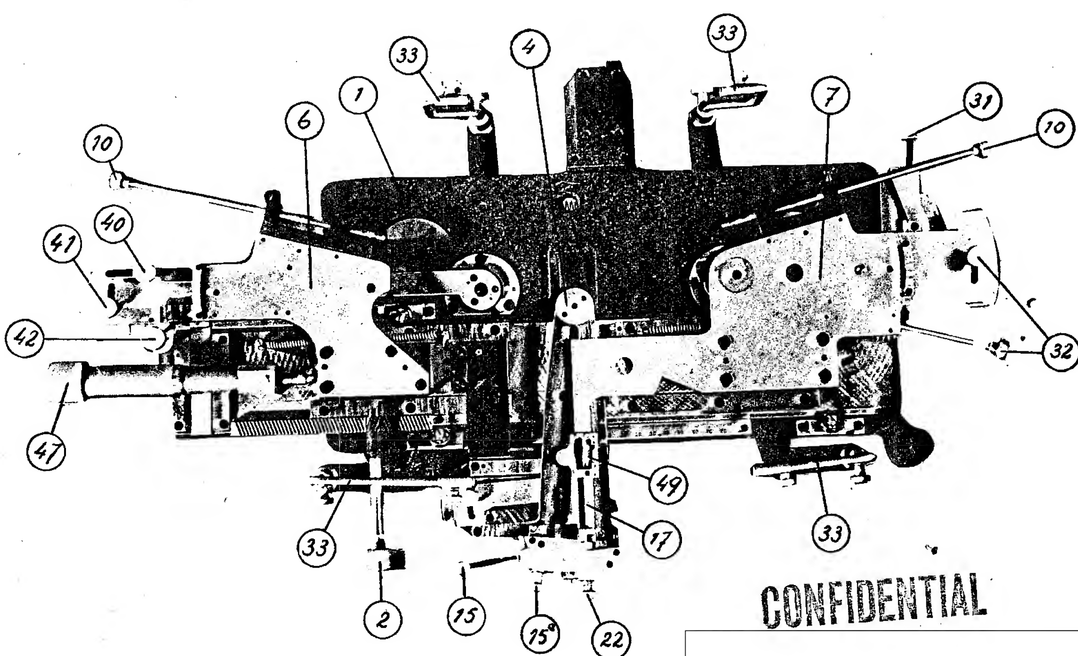
[redacted]

50X1-HUM

CONFIDENTIAL

50X1-HUM





CONFIDENTIAL

FIG.2

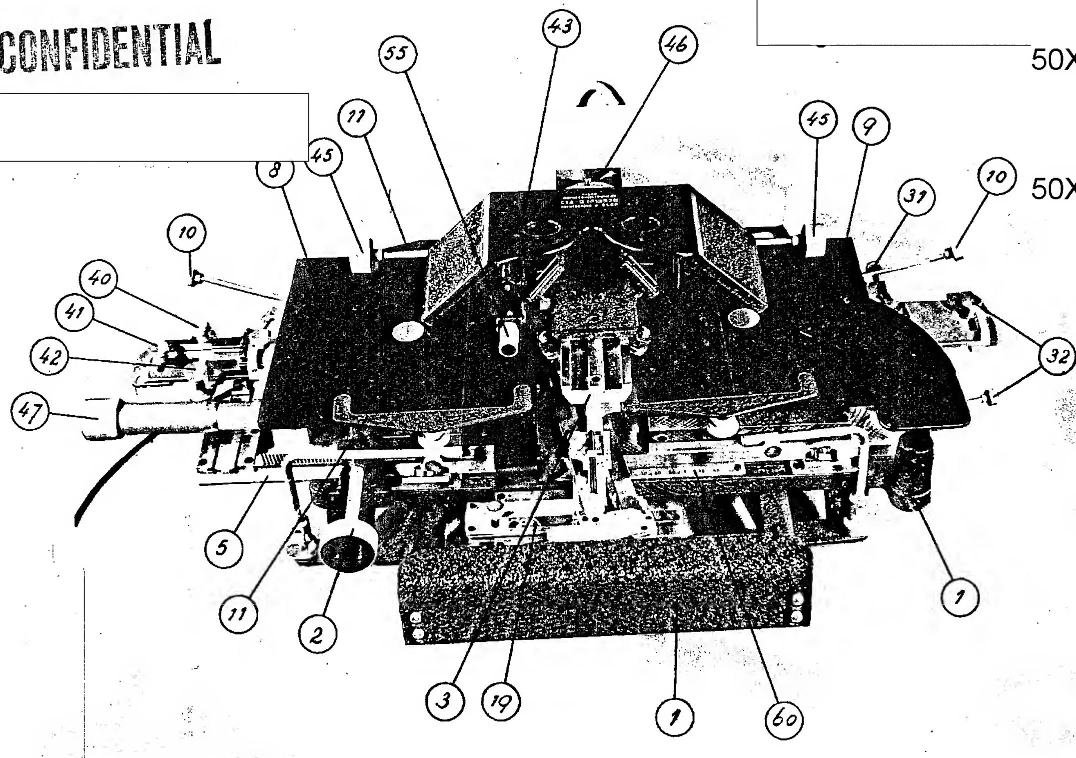
50X1-HUM

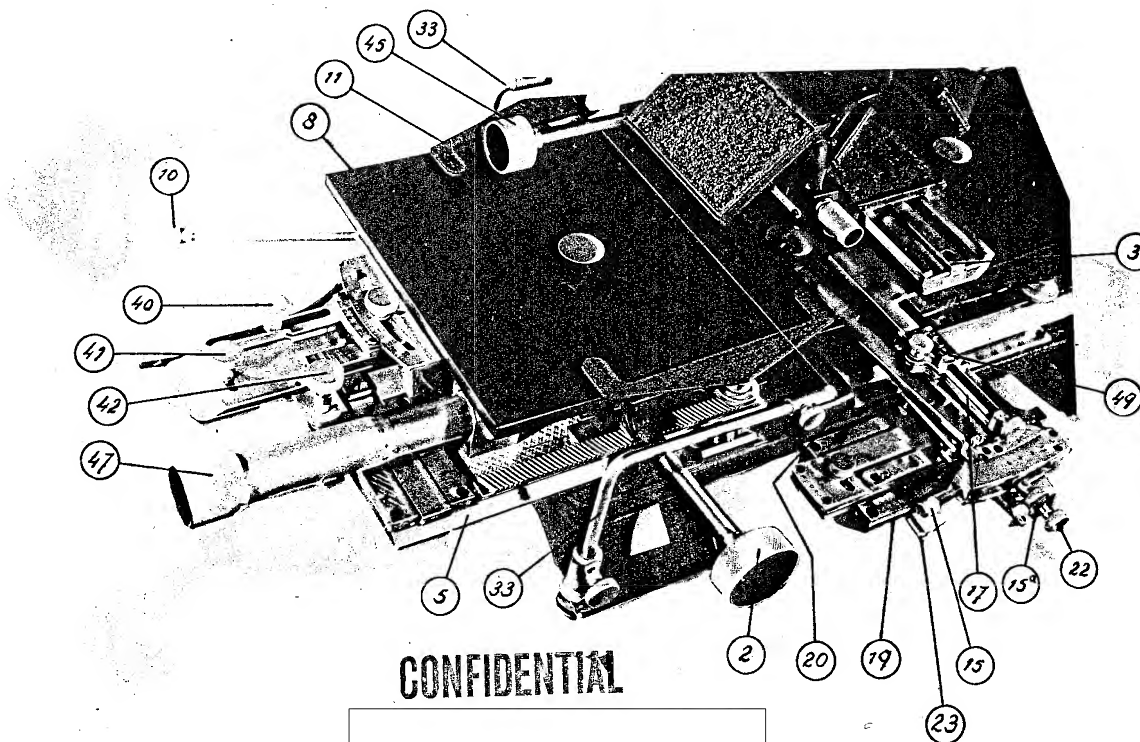
The instrument with removed stereoscope and plate-holders

CONFIDENTIAL

50X1-HUM

50X1-HUM





CONFIDENTIAL

50X1-HUM

FIG.I

General view of the STD-2

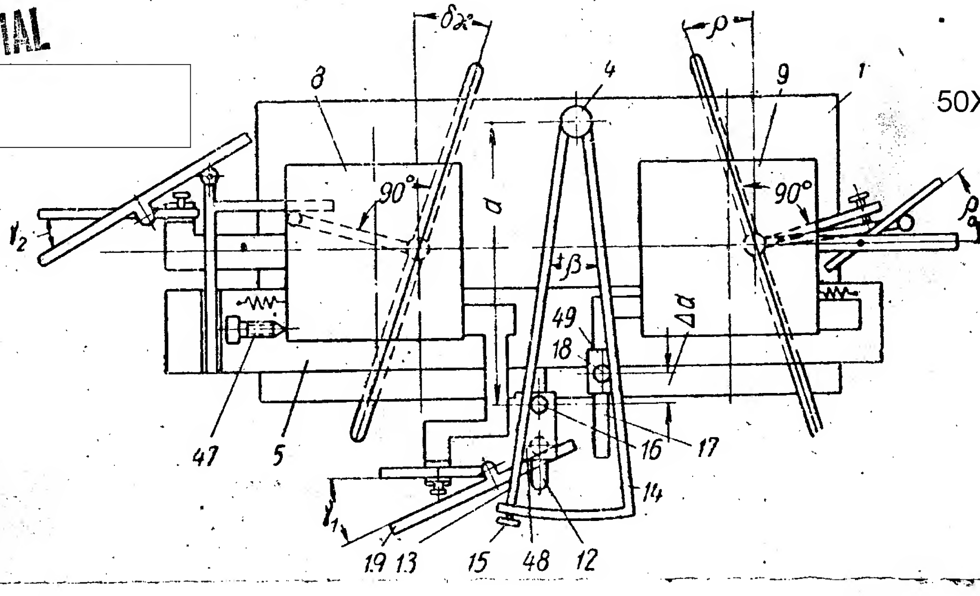
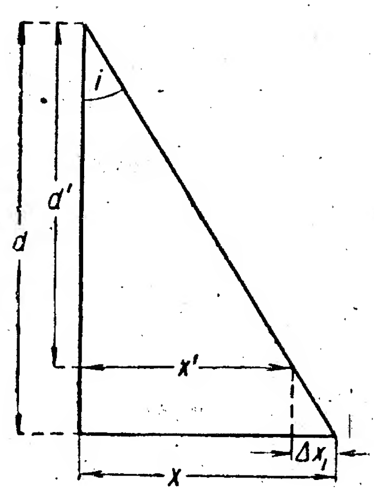


FIG. 3

General view of the instrument (plan)



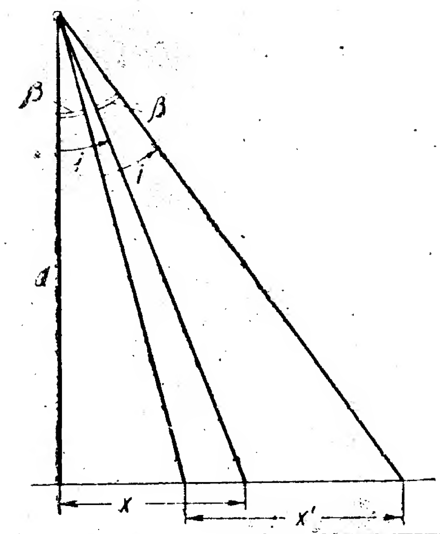


FIG. 4

Influence of the lengths of the rulers on the abscissa

FIG. 5

Influence of the angle between the rulers on the abscissa

50X1-HUM

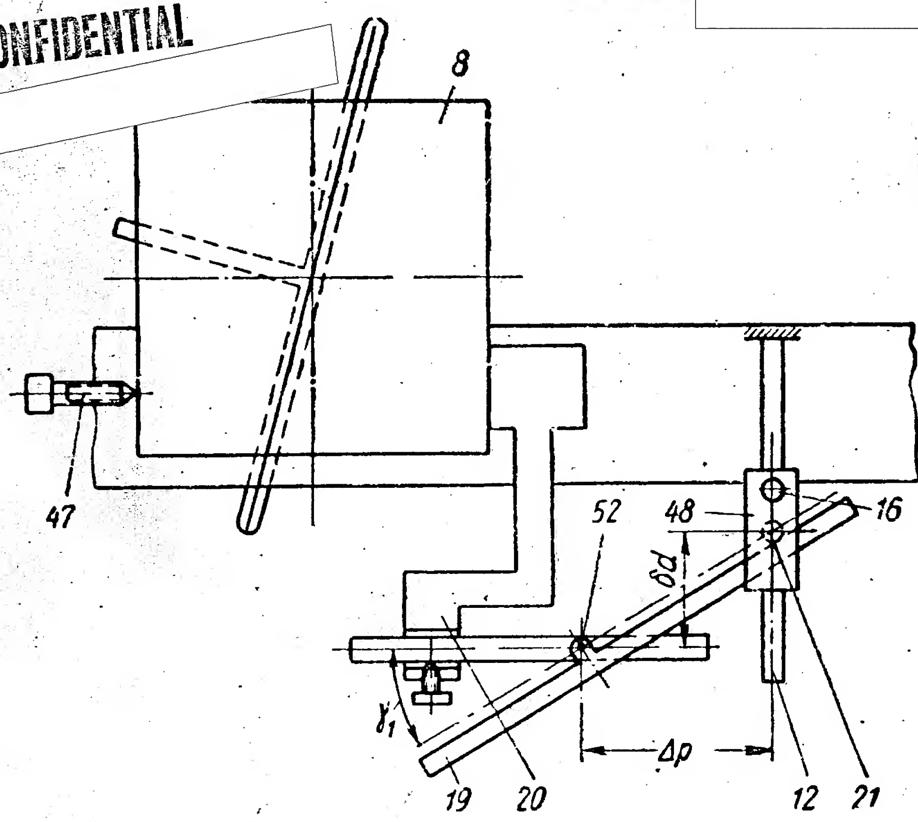
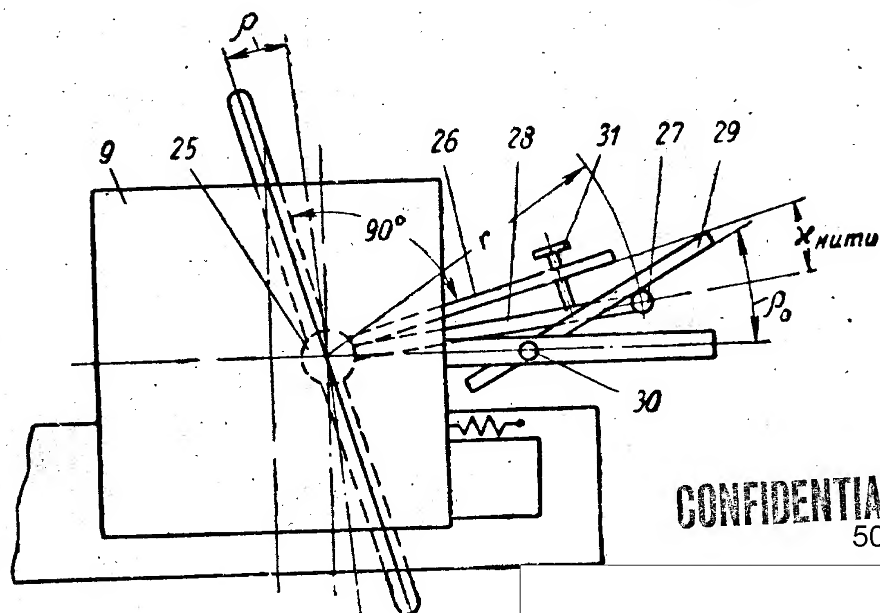


FIG. 6

The correction device for the change of the lengths of the ruler D



CONFIDENTIAL

50X1-HUM

FIG. 8

Rotation of the right thread

Sanitized Copy Approved for Release 2010/10/06 : CIA-RDP80T00246A055200040001-4

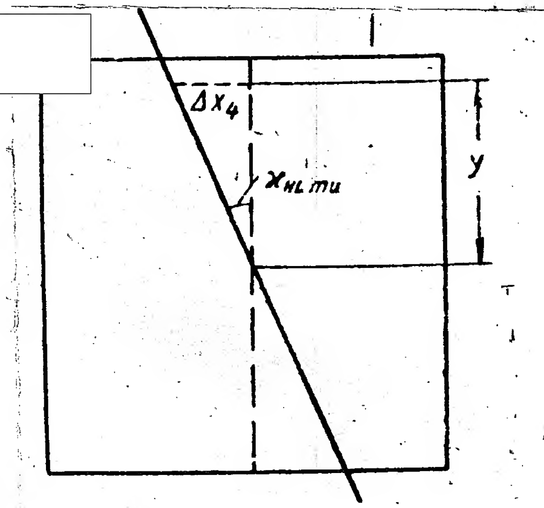


FIG. 9

Influence of the constant
deflection of the right thread
on the abscissa

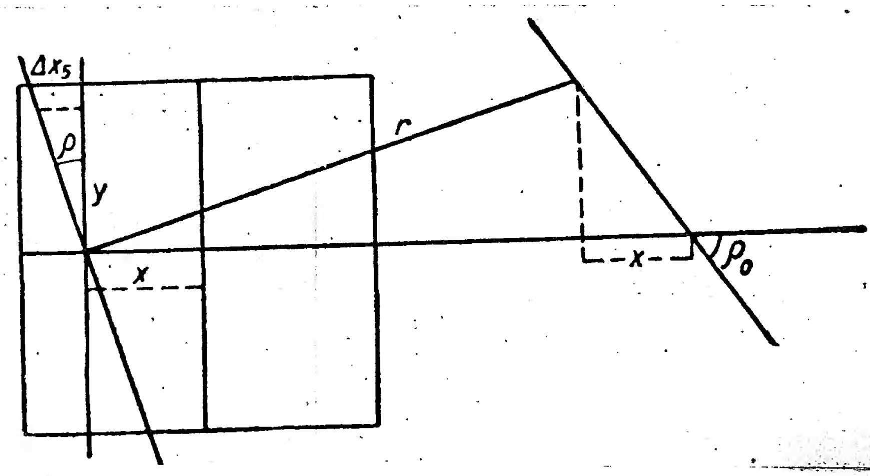


FIG. 10

Influence of the variable deflection of
the thread on the abscissa

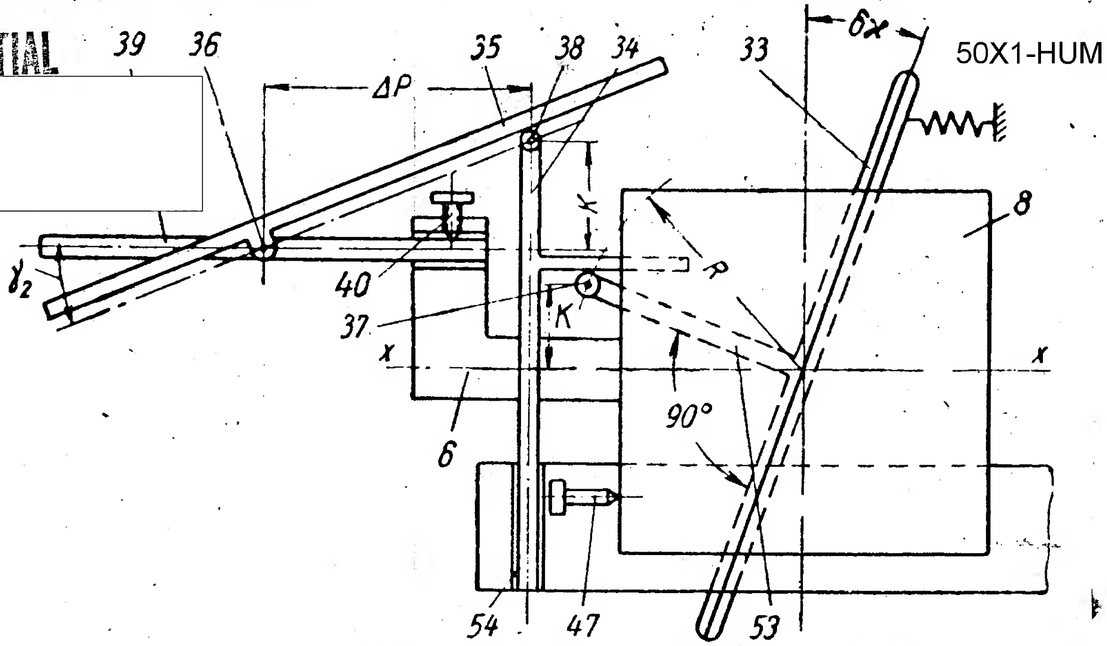


FIG. 11

Deflection mechanism of the left thread

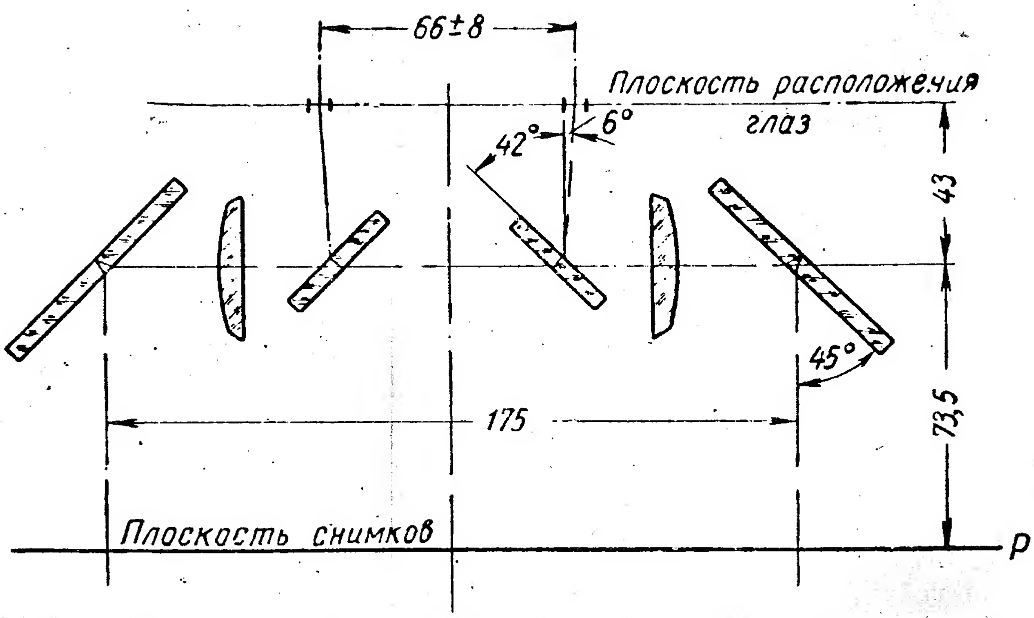


FIG 12

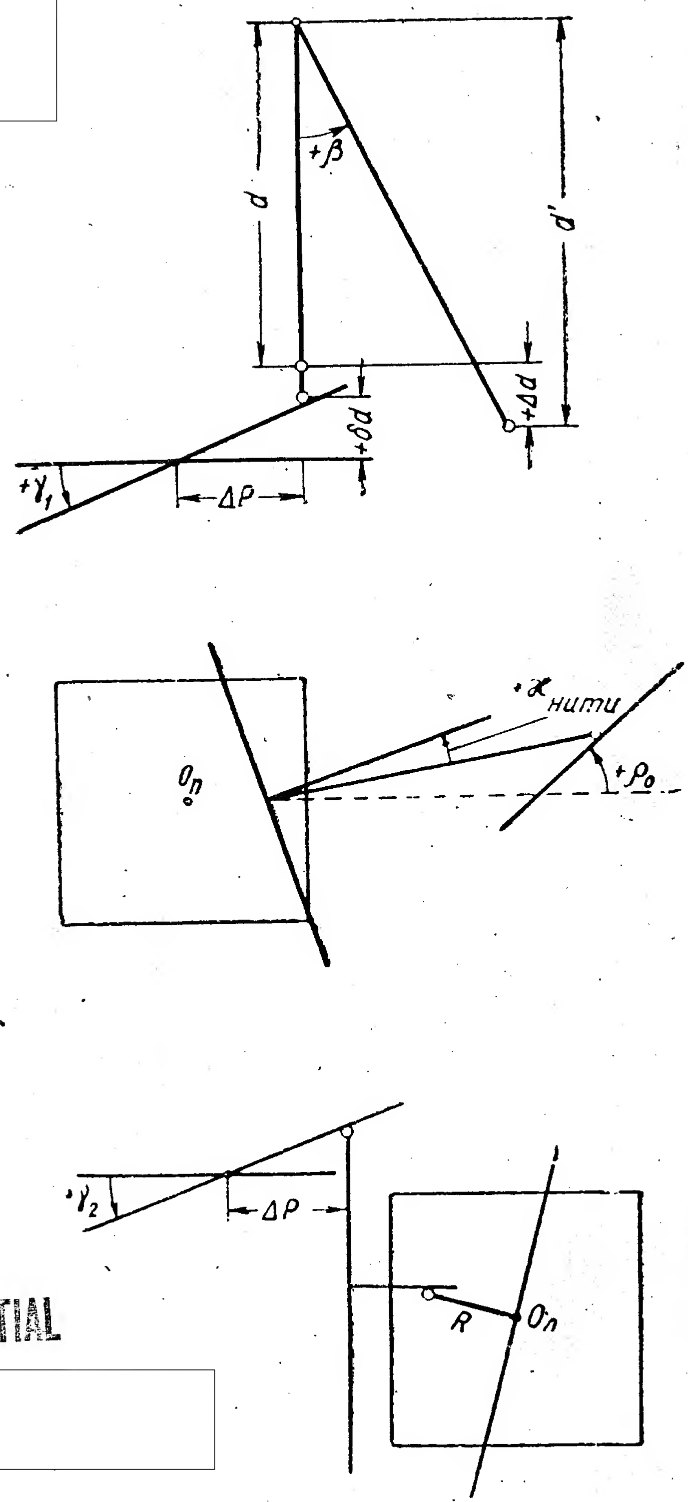
Diagram of the stereoscope

Plane of arrangement
eye

Plane of photographs

CONFIDENTIAL

50X1-HUM



CONFIDENTIAL

50X1-HUM

FIG. 13

Signs of the correction devices of the instrument

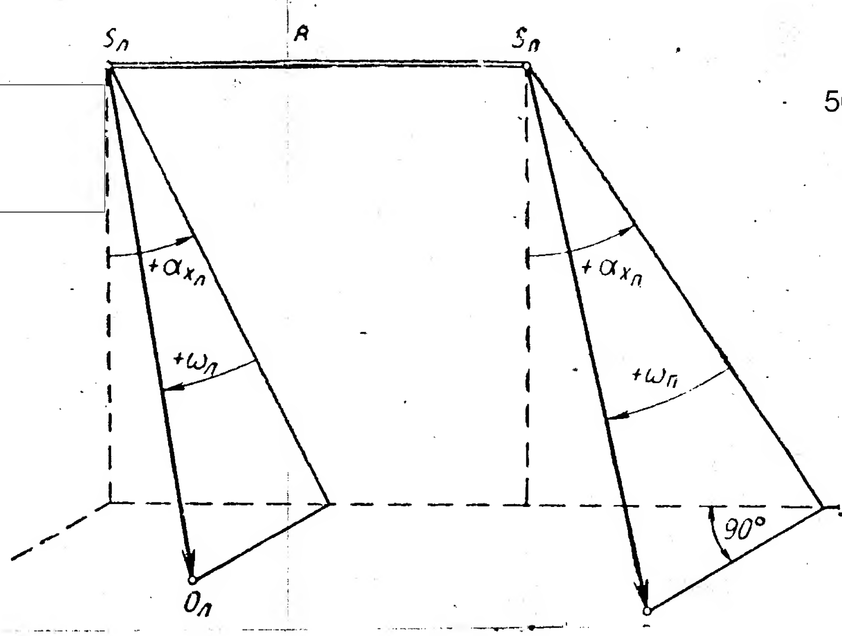
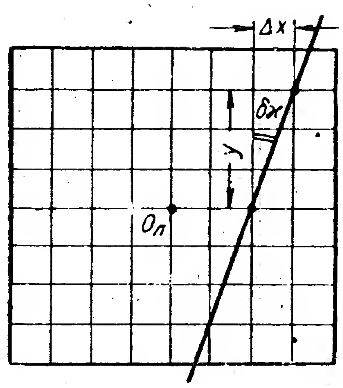


FIG.14

Signs of the longitudinal and transversal tilt



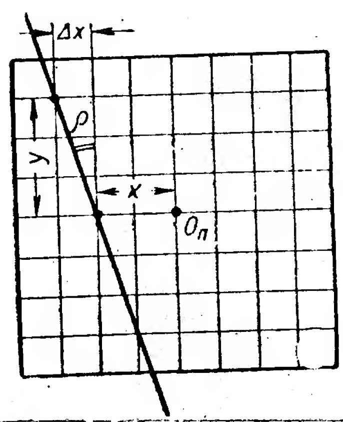


FIG.15

Determination of the rotation radius of the left thread holder

FIG.16

Determination of the rotation radius of the right thread holder